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Environmental Effects of Dredging Technical Notes

COMPUTERIZED DATABASE FOR INTERPRETATION OF THE RELATIONSHIP BETWEEN CONTAMINANT TISSUE RESIDUES AND BIOLOGICAL EFFECTS IN AQUATIC ORGANISMS

PURPOSE: This note provides initial information on the format and potential application of a computerized database in conducting certain types of literature searches. The ultimate goal of this task is to provide Corps elements with numerical as well as descriptive guidance so that they can relate contaminant tissue residues to biological effects in aquatic organisms in a more accurate, consistent, and technically defensible fashion.

BACKGROUND: Over the last 10 years, only a small number of sediments evaluated in regulatory testing programs have been found to be acutely toxic. Consequently, decisionmakers have relied less on toxicity and more heavily on bioaccumulation information. Unfortunately, there is little generally accepted interpretive guidance regarding the biological importance of bioaccumulation in aquatic organisms (Peddicord and Hansen 1983). In an effort to provide some initial guidance in this area, an assessment of the literature was conducted under the Long-Term Effects of Dredging Operations (LEDO) Program in which the association between bioaccumulation and biological effects in aquatic organisms was examined (Dillon 1984). Major findings of this initial literature review and assessment can be summarized as follows:

a. Only 6 percent of 2181 publications reporting biological effects information also contained contaminant residue data. This narrow database effectively limits numerical identification of specific biological threshold concentrations.

b. Of all the available biological end points to consider, reproductive effects as well as some measure of growth in aquatic organisms appear to be the best candidates for the subacute bioassessment of dredged material in a regulatory program.

c. Whole-animal (organismic) evaluations represent a reasonable and technically defensible compromise between biochemical assessments, which are potentially more sensitive, and population/community assessments, which generally have more ecological relevance.

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d. A majority (67 percent) of 2181 publications reported exposure of aquatic organisms to contaminants dissolved in aqueous solution. Only 7 percent evaluated the biological effects after exposure to contaminated sediment.

Based on results of the initial review of the literature, a more intensive look at the reproductive end point was undertaken by Dillon and Gibson (1985). They reported on the most frequently examined contaminant (cadmium), organism (fish), and reproductive end point (hatching success). In an effort to increase the number of reports considered for review (see subparagraph a above), published bioconcentration factors (BCF) were used by Dillon and Gibson to estimate tissue concentrations from data in those papers containing biological effects data but no tissue residue information.

Both of these assessments of published literature and the numerical calculations contained within them were performed manually using index cards and desk calculators. To provide a more rapid and comprehensive information retrieval system, computer hardware and appropriate software were acquired. This technical note describes progress to date in application of the system to develop and test a database from the literature on sublethal effects of contaminants in aquatic organisms.

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The Computerized Database: An Overview

In the spring of 1986, appropriate computer software to carry out an automated literature assessment was identified. The program was initially designed in 1983 and evolved into two software components: the Manager and the Searcher. A third component, the Editor, was added in 1986.

The program is the first text management system designed especially for bibliographic citations. Each citation entered can be any length and format and can include any additional descriptive notes of interest. Searches can be conducted by specifying any character, word, name, or phrase that is found anywhere in any entry or by specifying unique accession numbers assigned to the entries.

The Manager lets the operator manage information with minimum effort and maximum flexibility. Data are organized into records, which are units of related information contained in specific fields. The names of the fields are stored in a template, which can be easily designed or customized by the user to fit specific needs or preferences. A bibliographic template ordinarily

consists of fields such as author, title, year, journal, keywords, etc. Additional fields can be added to build a powerful database of information gleaned from the literature. An example is described in the next section.

Using the file system, information can be stored, sorted, searched, and retrieved quickly and efficiently. The Manager can search an entire record or selected fields for specific words and phrases, sort records by as many as six criteria (or keys), and generate reports.

Each of the three software products is designed to work independently of the others; at the same time, all three can be integrated to organize and process information in countless ways. The Searcher enables the user to access hundreds of on-line databases available from five different on-line services: BRS, DIALOG, NLM, ORBIT, and QUESTEL. Records from these databases can be downloaded and then transferred to user files with the Manager. The Editor lets the operator develop formats for bibliographic citations and use references stored by the Manager or downloaded by the Searcher from on-line databases. References can be easily formatted to meet organization- or journal-specific literature citation requirements.

Computerized Literature Review

The program is being used to conduct an assessment of the literature on sublethal effects of contaminants on aquatic organisms and to evaluate the software system, which was installed on a microcomputer running under PC-DOS. The input of data for the review, which began in May 1986, and the system evaluation are described in the following paragraphs.

Before a keyboard entry can be made of information retrieved from the open literature, a file of records must be created. An example of the input format for a record of the BIOCON (biological consequences) user file in the Manager is shown in Figure 1. For every paper that is reviewed, the following information is recorded into a template: author, reference (REF); biological response; contaminant (CONTAM); species; phylogeny (PHYLOG); aquatic medium; tissues; route of exposure; whether tissue concentrations were reported or estimated (R.VS.E.); life stages; contaminant exposure time; exposure concentration (EXP CON); tissue concentration (TIS CON) if reported or estimated; and any observed change in reproductive activity (EFFECTS).

Each publication is examined for reports of the highest tissue

User File: BIOCON Template: 14 Accession Number: 17

AUTHOR	Biesinger, K. E., L. E. Anderson and J. G. Eaton 1982
REF	Chronic effects of inorganic and organic mercury on *Daphnia magna*: toxicity, accumulation and loss. Arch. Environ. Contam. Toxicol. 11:769-744
RESPONSE	reproduction
CONTAM	mercury
SPECIES	water flea (*Daphnia magna*)
PHYLOG	Arthropoda, Crustacea
AQ.MED.	fresh water
TISSUES*	whole body, wet weight
ROUTE	water
R.VS.E.	R.
STAGES	12 ± 12 hr
TIME	21 days

EXP CON	reproduction	$HgCl_2$	water flea	0.36-0.72 µg/ℓ 1.28 2.70
TIS CON	reproduction	$HgCl_2$	water flea	8.13-17.15 µg/g 28.90 60.93
LEC	reproduction	$HgCl_2$	water flea	28.90 µg/g
HNEC	reproduction	$HgCl_2$	water flea	17.15 µg/g

EFFECTS — reproduction $HgCl_2$:

- 0.36-0.72 µg/ℓ - no effect on number of young produced
- 1.28 µg/ℓ - decreased number of young produced
- 2.70 µg/ℓ - 100% mortality

COMMENTS

* Tissue concentrations are reported in units of micrograms per gram (µg/g) wet weight. Data originally reported on a dry-weight basis were converted to wet weight assuming 80-percent body water.

Figure 1. Sample format for record in the Manager

concentration at which no effect on reproduction was observed, as well as for the lowest tissue concentration at which an effect was observed. These values are entered as the Highest No Effects Concentration (HNEC) and the Lowest Effects Concentration (LEC). Tissue concentrations are expressed on a wet-weight basis. Exposure concentrations are expressed in micrograms per liter (parts per billion) unless noted otherwise.

The use of the program in performing a literature review makes data entry quick and efficient. Moreover, records formatted with templates may be searched and sorted in numerous ways. For example, one may be reviewing the results of a 10-day bioaccumulation study involving contaminated sediment and polychaete worms. To assist in interpreting the results of the test, the database would be searched for all citations dealing with polychaetes, and a summary of the results could be requested. Likewise, if one would like to know the relative toxicity of various contaminants, relevant literature could be accessed and summarized. The search can be tailored to individual needs such as fresh water versus salt water, specific organisms, and/or various contaminants, etc.

The program lacks one capability that proved to be a limitation during the present literature review. All characters, including numbers, are treated as text and thus cannot be used for arithmetic computations. A user could retrieve all HNEC data relating to a specific contaminant, for example, but could not use the program to calculate a mean of the HNEC values. This limitation also means that comparison operators (<, >, etc.) are not available for searches. A user would not be able to search for all HNEC greater than a specified value, for example. It is hoped that this limitation will be addressed in future product upgrades. For the present, this disadvantage is considered to be minor and is far outweighed by the power, simplicity, and modest cost of the system.

Future Plans

Efforts will continue on establishing the database and making the system available to Corps field offices. Meanwhile, persons requiring numerical and/or descriptive information relating tissue residues to biological effects in aquatic organisms may contact the authors of this technical note.

References

Dillon, T. M. 1984. "Biological Consequences of Bioaccumulation in Aquatic Animals: An Assessment of the Current Literature," Technical Report D-84-2, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Dillon, T. M., and Gibson, A. B. 1985. "Bioaccumulation and Effects on Reproduction in Aquatic Organisms: An Assessment of the Current Literature," Miscellaneous Paper D-85-2, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Peddicord, R. K., and Hansen, J. C. 1983. Technical implementation of the regulations governing ocean disposal of dredged material. In: *Wastes in the Ocean. Vol. II: Dredged Material Disposal in the Ocean*, D. R. Kester, B. H. Ketchum, I. W. Duedall, and P. K. Parks (eds.), John Wiley and Sons, Inc., New York, pp 71-88.